Science of the Total Environment 780 (2021) 146481

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Influences of pesticides, nutrients, and local environmental variables on phytoplankton communities in lentic small water bodies in a German lowland agricultural area

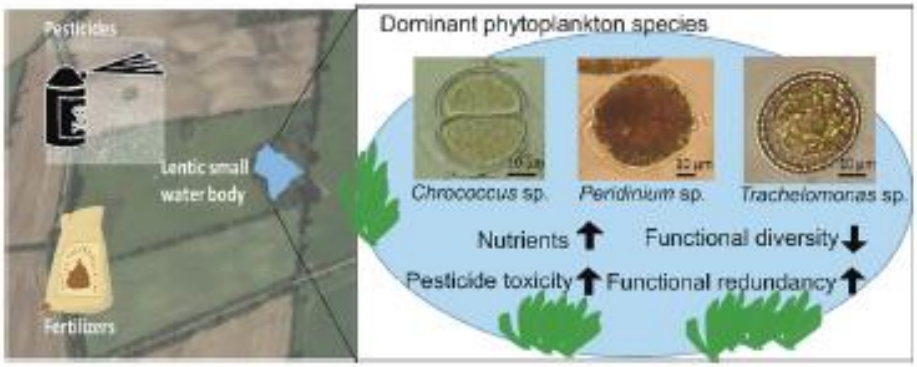
Lishani Wijewardene [a,b], Naicheng Wu [a,c,*], Yueming Qu [a], Kun Guo [b], Beata Messyasz [d], Stefan Lorenz [e], Tenna Riis [b,f], Uta Ulrich [a], Nicola Fohrer [a]

[a] Department of Hydrology and Water Resources Management, Institute for Natural Resource Conservation, Kiel University, 24118 Kiel, Germany
[b] Department of Biology, Aarhus University, Ole Worms Allé 1, 8000 Aarhus C, Denmark
[c] Department of Geography and Spatial Information Techniques, Ningbo University, 315211 Ningbo, China
[d] Department of Hydrobiology, Institute of Environmental Biology, Faculty of Biology, Adam Mickiewicz University in Poznan, Uniwersytetu Poznanskiego 6, 61-614 Poznan, Poland
[e] Julius Kuehn-Institute, Institute for Ecological Chemistry, Plant Analysis and Stored Product Protection, Koenigin-Luise-Str. 19, 14195 Berlin, Germany
[f] WATEC, Aarhus University Centre for Water Technology, Department of Biology, 8000 Aarhus C, Denmark

HIGHLIGHTS

- Pesticides and nutrients are concurrent stressors in lentic small water bodies.
- Pesticide toxicity and nutrients affect phytoplankton community composition.
- Functional diversity reduced with increasing nutrient concentrations.
- Functional redundancy increased with increasing pesticide toxicity.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 21 November 2020
Received in revised form 11 February 2021
Accepted 10 March 2021
Available online 16 March 2021

Editor: Dimitra A Lambropoulou

Keywords:
Multiple stressors
Agrochemicals
Pesticide and nutrient enrichment
Species composition
Functional diversity
Functional redundancy

ABSTRACT

Agrochemicals such as pesticides and nutrients are concurrent chemical stressors in freshwater aquatic ecosystems surrounded by agricultural areas. Lentic small water bodies (LSWB) are ecologically significant habitats especially for maintaining biodiversity but highly understudied. Phytoplankton are ideal indicator species for stress responses. Functional features of the phytoplankton are important in revealing the processes that determine the structure of the communities. In this study, we investigated the effects of pesticides, nutrients, and local environmental variables on the species composition and functional features of phytoplankton communities in LSWB. We studied pesticide toxicity of ninety-four pesticides, three nutrients (NH_4-N, NO_3-N and PO_4-P) and local environment variables (precipitation, water level change, temperature, dissolved oxygen concentration, electrical conductivity, pH) in five LSWB over twelve weeks during the spring pesticide application period. We explored respective changes in species composition of phytoplankton community and functional features. Redundancy analysis and variance partitioning analysis were applied to correlate phytoplankton community compositions with the pesticide toxicity (as maximum toxicity in toxic units), nutrients and local environment variables. We used multiple linear regression models to identify the main environmental variables driving the functional features of phytoplankton communities. Pesticide toxicity, nutrients and local environmental variables significantly ($p < 0.001$) contributed to shaping phytoplankton community composition individually. Local environment variables showed the highest pure contribution for driving phytoplankton composition (12%), followed by

* Corresponding author at: Department of Hydrology and Water Resources Management, Institute for Natural Resource Conservation, Kiel University, 24118 Kiel, Germany.
E-mail address: nwu@hydrology.uni-kiel.de (N. Wu).

https://doi.org/10.1016/j.scitotenv.2021.146481

nutrients (8%) and pesticide toxicity (2%). Functional features (represented by functional diversity and functional redundancy) of the phytoplankton community were significantly affected by pesticide toxicity and nutrients concentrations. The functional richness and functional evenness were negatively affected by PO_4-P concentrations. Pesticide toxicity was positively correlated with functional redundancy indices. Our findings emphasized the relative importance of concurrent multiple stressors (e.g., pesticides and nutrients) on phytoplankton community structure, directing potential effects on metacommunity structures in aquatic ecosystems subjected to agricultural runoff.